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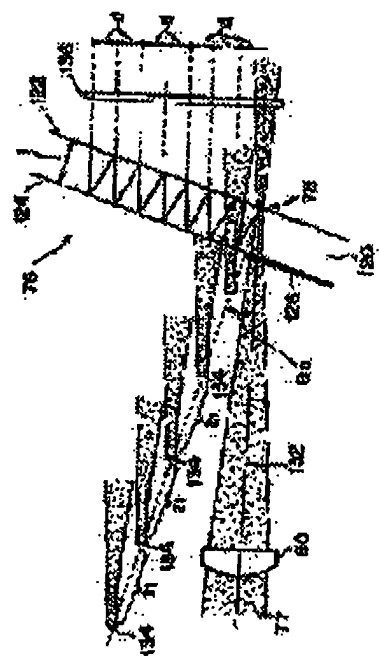
(54) VIRTUALLY IMAGED PHASED ARRAY (VIPA) HAVING SURFACE OF CHANGING IN REFLECTIVITY IN ORDER TO IMPROVE BEAM PROFILE

(57)Abstract:
PROBLEM TO BE SOLVED: To enable the simultaneous sepn. of plural carriers from wavelength division multiplex light with simple constitution by constituting the array in such a manner that input light is reflected plural times between first and second surfaces and that a plurality of the light passes the array via the second surface.
SOLUTION: The virtually imaged phased array(VIPA) 76 includes a plate 120 made of, for example, glass and has reflection films 122 and 124 thereon. The input light 77 is focused at a focal line 78 by a lens 80 via an irradiation window and multiple reflection is induced between the reflection films 122 and 124. The reflection surface 124 has approximately 100% reflectivity exclusive of the irradiation window and the reflection surface 122 has approximately 95% or higher reflectivity. Then, the reflection surface 122 has approximately 5% or lower transmissivity to allow the transmission of approximately 5% or lower the incident light on the reflection surface 122 and reflects 95% or more of the light. The reflectivities of the reflection surfaces 122 and 124 are easily changeable if the specific application of VIPA is complied.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention receives a bar CHARI IMEJIDO phased array (VIPA:virtually imaged phased array), i.e., the wavelength division multiplex light which consists of two or more carriers, corresponds wavelength division multiplex light to two or more carriers, respectively, and relates to the wavelength splitter mutually separated spectrally into two or more distinguishable flux of lights spatially.
[0002]
[Description of the Prior Art] A wavelength division multiplex is high speed, and in order to transmit comparatively a lot of data, it is used in fiber optics communication. In more detail, it is multiplexed and two or more carriers modulated using information, respectively are made into wavelength multiplex light. Wavelength division multiplex light is transmitted to a receiver through one optical fiber from it. A receiver separates wavelength division multiplex light spectrally into each carrier, and detects each carrier. Thus, communication system can transmit comparatively a lot of data using an optical fiber.
[0003] Therefore, the capacity for a receiver to separate wavelength division multiplex light spectrally correctly influences the performance of communication system greatly. For example, such a wavelength division multiplex light should not be transmitted if a receiver cannot separate wavelength division multiplex light spectrally correctly even if it multiplexs and can do many carriers in wavelength division multiplex light. Therefore, a receiver is wanted to have the highly precise wavelength splitter.
[0004] Drawing 1 is drawing showing the conventional filter using the multilayer interference film for using it as a wavelength splitter. According to drawing 1 , the multilayer interference film 20 is formed on the transparent substrate 22. Although this must be parallel light, incidence of the light 24 is carried out on a film 20, and it is reflected within the repeat film 20. Only the light 26 of wavelength lambda 2 can be penetrated according to the optical conditions determined with the property of a film 20. A film 20 is not penetrated but light 28 is reflected, although this contains all the light that does not fulfill optical conditions. Therefore, the filter shown in drawing 1 is useful although the wavelength division multiplex light only containing two carriers of different wavelength lambda1 and lambda2 is separated spectrally. However, the wavelength division multiplex light which has many carriers from 2 cannot be separated spectrally such a filter and in itself.
[0005] Drawing 2 is drawing showing the conventional Fabry-Perot interferometer used as a wavelength splitter. According to drawing 2 , the high reflection factor reflective films 30 and 32 are mutually parallel. Although this must be parallel light, on the reflective film 30, incidence of the light 34 is carried out and it is reflected among the reflective films 30 and 32 many times. The light 36 of wavelength lambda 2 which fulfills the transparency conditions determined with the property of a Fabry-Perot interferometer penetrates the reflective film 32. The light 38 of wavelength lambda 1 which does not fulfill transparency conditions is reflected. Thus, it is separated spectrally into two different light corresponding to two different wavelength, respectively, and deals in the light which has two different wavelength. Thus, like the filter shown

in drawing 1 , the conventional Fabry-Perot interferometer is useful, although the wavelength division multiplex light only containing two carriers of different wavelength lambda1 and lambda2 is separated spectrally. However, such a Fabry-Perot interferometer cannot separate spectrally the wavelength division multiplex light which has many carriers from 2.

[0006] Drawing 3 is drawing showing the conventional Michelson interferometer used as a wavelength splitter. According to drawing 3 , incidence of the parallel light 40 is carried out to a one-way mirror 42, and it is mutually separated spectrally into the 1st perpendicular light 44 and 2nd perpendicular light 46. The reflective mirror 48 reflects the 1st light 44, and the reflective mirror 50 reflects the 2nd light 46. The distance of a one-way mirror 42 and the reflective mirror 48 and the distance of a one-way mirror 42 and the reflective mirror 50 show the optical path difference. It is returned to a one-way mirror 42, and is reflected by the reflective mirror 50, and the light reflected by the reflective mirror 48 interferes with the light returned to a one-way mirror 42. As a result, the light 52 and 54 which has wavelength lambda1 and lambda2 is separated mutually. Like the filter of drawing 1 , and the Fabry-Perot interferometer of drawing 2 , the Michelson interferometer of drawing 3 is useful, although the wavelength division multiplex light only containing two carriers of different wavelength lambda1 and lambda2 is separated spectrally. However, such a Michelson interferometer cannot separate spectrally the wavelength division multiplex light which has many carriers from 2.

[0007] It is possible to make it a big array combining some filters, a Fabry-Perot interferometer, or a Michelson interferometer, and to enable it to separate the further wavelength carrier from one wavelength division multiplex light. However, such an array will be expensive, it will be inefficient-like, and such a big receiver will be constituted that it does not consider.

[0008] A diffraction grating and a waveguide array grid are often used for separating spectrally the wavelength division multiplex light which consists of two or more different wavelength carriers. Drawing 4 is drawing showing the conventional diffraction grating for separating wavelength division multiplex light spectrally. According to drawing 4 , the diffraction grating 56 has the concavo-convex field 58. Incidence of the parallel light 60 which has the wavelength carrier with which plurality differs is carried out to the concavo-convex side 58. It is reflected and interferes in each wavelength carrier between the reflected lights from the step from which a grid differs. As a result, the carriers 62, 64, and 66 of different wavelength are outputted at an angle which is different from a diffraction grating 56, and each other are separated.

[0009] However, a diffraction grating outputs the carrier of different wavelength with a small angle difference relatively. Therefore, angular dispersion made by the diffraction grating will become very small. As a result, it becomes difficult for a receiver to receive correctly various carrier signals separated spectrally by the diffraction grating. This problem is serious especially in the diffraction grating which separates spectrally the wavelength division multiplex light which has many carriers with the wavelength which approached comparatively.

[0010] Furthermore, a diffraction grating is influenced by the optical polarization of an incident light. So, the polarization of an incident light can affect the performance of a diffraction grating. Moreover, in order to manufacture an accurate diffraction grating for the concavo-convex side of a diffraction grating, a complicated manufacturing process is needed.

[0011] Drawing 5 is drawing showing the conventional waveguide array grid for separating wavelength division multiplex light spectrally. According to drawing 5 , light is received through an input control port 68, and the light which consists of a wavelength carrier with which plurality differs branches to many waveguides 70. The optical output mouth 72 is in the edge of each waveguide 70, and generates the output light 74. The waveguide 70 has prepared the optical path of length which length differs mutually, therefore is different. Therefore, the light which passes a waveguide 70 forms an output 74 in the direction which has mutually different path length, therefore interferes mutually through an output 72, and is different to different wavelength.

[0012] In a waveguide array grid, angular dispersion can be adjusted to some extent by constituting a waveguide suitably. However, a waveguide array grid is influenced by the temperature change and other environmental factors. Therefore, it becomes difficult by the temperature change and the environmental factor to adjust a performance appropriately.

[0013] Therefore, the technical problem of this invention is easy composition, and is offering the

wavelength splitter which can separate two or more carriers from wavelength division multiplex light simultaneously. The further technical problem of this invention diffuses the separated carrier in comparatively big angular dispersion, resistance is in change of an environmental condition, and a desirable beam profile and 1 of them are offering the wavelength splitter which generates the flux of light as a result which has a beam profile symmetrical for the effective combination to an optical fiber.

[0014]

[Means for Solving the Problem] The technical problem of this invention is attained by offering the equipment which has the 1st and the 2nd field. The 2nd field has a reflection factor which a part of light which carried out incidence penetrates. Equipment receives the input light of each wavelength of continuation within the limits of wavelength. Multiple-times reflection of the input light is carried out between the 1st and the 2nd field, and the 1st and 2nd fields are arranged so that two or more light may penetrate through the 2nd field. It interferes in two or more transmitted lights mutually, and they generate a distinguishable output light spatially with the output light generated to the input light which has what other wavelength of continuation within the limits of wavelength. The reflection factor of the 2nd field changes along the 2nd field, and output light comes to have a desirable beam profile along the 2nd field. A phase regulation buffer layer can be prepared in order to make it the light reflected in the 1st field have a uniform optical phase along the 2nd field from the 2nd field. Furthermore, a phase regulation layer can be prepared in order to give a uniform optical phase to two or more transmitted lights along the 2nd field.

[0015] The technical problem of this invention can be attained also by offering the 1st which has a reflection factor which makes a part of light in which the 2nd field carried out incidence penetrate again, and equipment including the 2nd field. Equipment receives the input light of each wavelength condensed by the line. The 1st and the 2nd field are arranged so that input light may be emitted from a line, and multiple-times reflection may be carried out between the 1st and the 2nd field, therefore two or more light may penetrate through the 2nd field. Two or more transmitted lights generate a distinguishable output light spatially with the output light which interfered mutually and was generated to the input light of different wavelength. The reflection factor of the 2nd field changes along the 2nd field, and it is made for output light to have a desirable beam profile along the 2nd field.

[0016]

[Embodiments of the Invention] This suitable operation gestalt of this invention is stated here in detail. These examples are illustrated by the attached drawing. The same reference mark is ** which lets the whole pass and is given to the same component.

[0017] Drawing 6 is drawing showing the bar CHARI IMEJIDO phased array (VIPA) according to 1 operation gestalt of this invention. Furthermore, in order that a "wavelength splitter", a "bar CHARI IMEJIDO phased array", and the term of "VIPA" may describe various operation gestalten of this invention henceforth, it changes mutually and suppose that it is usable.

[0018] In drawing 6 , VIPA76 consists of thin plates of glass preferably. The input light 77 is condensed by the line 78 with a lens 80 like a semicircle cylinder lens, and the input light 77 progresses into VIPA76. A line 78 is henceforth called "focal line 78." The input light 77 is spread from the focal line 78 of the VIPA76 interior to a radial. Next, VIPA76 outputs the flux of light 82 of collimation light. Here, the output angle of the flux of light 82 changes as the wavelength of the input light 77 changes. For example, when the input light 77 is wavelength lambda 1, VIPA76 outputs flux of light 82a of wavelength lambda 1 in the specific direction. When the input light 77 is wavelength lambda 2, VIPA76 is outputted in the direction which is different in flux of light 82b of wavelength lambda 2. Therefore, VIPA76 generates the distinguishable flux of lights 82a and 82b spatially mutually. When the input light 77 contains both wavelength lambda1 and lambda2, VIPA76 outputs simultaneously both flux of lights 82a and 82b.

[0019] Drawing 7 is drawing according to 1 operation gestalt of this invention showing VIPA76 in detail. According to drawing 7 , VIPA76 has the reflective films 122 and 124 on it including the plate 120 made with glass. Preferably, the reflective film 122 is more than it from 95% of abbreviation, and has the reflection factor smaller than 100%. The reflective film 124 has the

reflection factor of 100% of abbreviation preferably. The irradiation window 126 is formed on the plate 120, and has the reflection factor of 0% of abbreviation preferably.

[0020] Through an irradiation window, it is condensed by the focal line 78 with a lens 80, and the input light 77 starts a multiple echo among the reflective films 122 and 124. The focal line 78 is preferably on the field of the plate 120 with which the reflective film 122 is formed. Essentially, the focal line 78 is a line condensed on the reflective film 122 through the irradiation window 126. The width of face of the focal line 78 can be called "beam waist" of the input light 77 at the time of being condensed with a lens 80. Therefore, the operation gestalt of this invention shown in drawing 7 condenses the beam waist of the input light 77 to the field (namely, field which has the reflective film 122 on it) of the distant one of a plate 120. By condensing a beam waist to the field of the distant one of a plate 120, with this operation gestalt of this invention (i) The field of the input light 77 when passing through the irradiation window 126 (for example, field which is described in detail by the following and which was shown in drawing 10 "a"), (ii) Possibility that a lap will arise between the fields (for example, field which is described in detail by the following and which was shown in drawing 10 "b") of the light on the reflective film 124 when the input light 77 is first reflected by the reflective film 124 is decreased. In order to guarantee suitable operation of VIPA, it is desirable to decrease such a lap.

[0021] Setting to drawing 7 , the optical axis 132 of the input light 77 is the small angle of inclination theta 0. It has. If the reflection factor of the reflective film 122 is assumed to be 95%, in reflection of the beginning of the reflective film 122, 5% of light will pass the reflective film 122, a beam waist will be back-spread, and 95% of light will be reflected toward the reflective film 124. After being first reflected by the reflective film 124, although light shines upon the reflective film 122 again, only the amount d has shifted. And 5% of light penetrates the reflective film 122. Similarly, as shown in drawing 7 , light branches on the path of fixed many which interval d Separated. The configuration of the beam of each path is formed so that light may diffuse from the virtual image 134 of a beam waist. The virtual image 134 is arranged at intervals of [fixed] 2t along with the line perpendicular to a plate 120. Here, t is the thickness of a plate 120. The position of the beam waist in a virtual image 134 is not arranged automatically, and does not need to adjust each position. It interferes in the light diffused from a virtual image 134 mutually, and it forms the collimation light 136 spread in the direction which changes according to the wavelength of the input light 77.

[0022] the interval of an optical path — d=2tSintheta0 it is — the difference of the path length between the adjoining beams — 2tCostheta0 it is . angular dispersion — these two numbers — comparatively — alike — it is proportional — **** — this ratio — cottheta0 it is . As a result, VIPA generates quite big angular dispersion.

[0023] The term "virtually imaged phased array" originates in formation of the array of a virtual image 134 so that drawing 7 may show easily. Drawing 8 is line VIII-VIII of VIPA76 shown in drawing 6 according to the operation gestalt of this invention. It is drawing showing the cross section which met. According to drawing 8 , the plate 120 has reflectors 122 and 124 on it. Reflectors 122 and 124 are mutually parallel and are isolated by thickness t of a plate 120. Typically, reflectors 122 and 124 are the reflective films formed on the plate 120. As mentioned above, the reflector 124 has the reflection factor of 100% of abbreviation except for the irradiation window, and the reflector 122 has the reflection factor beyond 95% of abbreviation, or it. Therefore, the reflector 122 has the permeability not more than 5% of abbreviation, or it. less than [5% of abbreviation or it of the incident light to a reflector 122] is made to penetrate, and more than 95% or it of light is reflected. The reflection factor of reflectors 122 and 124 can be easily changed, if special application of VIPA is followed. However, generally, the reflector 122 should have the reflection factor smaller than 100% in order to make a part of incident light penetrate.

[0024] The reflector 124 has the irradiation window 126 on it. The irradiation window 126 makes light penetrate and completely has the low reflection factor very much without the reflective power preferably. The irradiation window 126 receives the input light 77, makes the input light 77 receive among reflectors 122 and 124, and is reflected.

[0025] Drawing 8 is line VIII-VIII of drawing 6 . Since the cross section which met is shown, the

focal line 78 of drawing 6 has appeared as a "point" in drawing 8 . The input light 77 is spread from the focal line 78 from it to a radial. Furthermore, the focal line 78 is arranged at the reflector 122 as shown in drawing 8 . Although the focal line 78 is not required for being on a reflector 122, movement of the position of the focal line 78 results in a slight change to the property of VIPA76.

[0026] Incidence of the input light 77 is carried out to a plate 120 through the field A0 of the irradiation window 126 as shown in drawing 8 . Here, the point P0 shows the point around a field A0.

[0027] With the reflection factor of a reflector 122, it is reflected by the reflector 122 and more than 95% of abbreviation or it of the input light 77 carries out incidence on the field A1 of a reflector 124. After reflecting from the field A1 of a reflector 124, the input light 77 progresses to a reflector 122, and penetrates a reflector 122 as an output light Out1 as which a part is specified with a beam of light R1. Thus, the input light 77 starts a multiple echo among reflectors 122 and 124 as shown in drawing 8 . Here, each reflection from a reflector 122 serves as each output light penetrated again. Following [for example,], it is reflected in fields A2, A3, and A4, and the input light 77 generates the output light Out2, Out3, and Out4. A point P2 shows the point around a field A2, a point P3 shows the point around a field A3, and the point P4 shows the point around a field A4. The output light Out2 is prescribed by the beam of light R2, the output light Out3 is prescribed by the beam of light R3, and the output light Out4 is prescribed by the beam of light R4. Although drawing 8 is illustrating only the output light Out0, Out1, Out2, Out3, and Out4, more much output light exists with the power of the input light 77, and the reflection factor of reflectors 122 and 124 in fact. It interferes in output light mutually and it generates the flux of light which has the direction which changes according to the wavelength of the input light 77 so that it may state in detail by the following.

[0028] Drawing 9 is drawing according to 1 operation gestalt of this invention showing interference generated by VIPA. According to drawing 9 , the light which progresses from the focal line 78 is reflected by the reflector 124. As mentioned above, the reflector 124 has the reflection factor of 100% of abbreviation, therefore essentially functions as a mirror. as a result -- the output light Out1 -- reflectors 122 and 124 -- there is nothing -- the output light Out1 -- focal line I1 from -- as emitted, it can analyze optically the same -- the output light Out2, Out3, and Out4 -- these -- the focal line I2, I3, and I4 from -- it can be optically analyzed as having been emitted, respectively The focal line I1, I2, I3, and I4 Focal line I0 It is a virtual image.

[0029] therefore, it is shown in drawing 9 -- as -- focal line I1 Focal line I0 from -- it is in the place of 2t of distance Here, t is equal to the distance between reflectors 122 and 124. Similarly, the focal line of each consecutiveness is in the place of 2t of distance from the last focal line. Thus, focal line I2 Focal line I1 It is in the place of 2t of shell distance. Furthermore, the multiple echo of each consecutiveness between reflectors 122 and 124 generates output light with intensity smaller than a front output light. Therefore, the output light Out2 has intensity smaller than the output light Out1.

[0030] The output light from a focal line laps mutually, and it interferes in it as shown in drawing 9 . This interference generates the flux of light which progresses in the specific direction depending on the wavelength of the input light 77. VIPA according to the above-mentioned operation gestalt of this invention has the conditions which suit in the slight strength which is a property on the design of VIPA. The conditions which suit in slight strength increase interference of output light, and the flux of light is formed. The conditions which suit in the slight strength of VIPA are expressed by the following formulas (1).

[0031] 2txcostheta=mlambda -- here, theta is the propagation direction of the formed flux of light measured from the line perpendicular to the field of reflectors 122 and 124 lambda shows the wavelength of input light, t shows the distance between reflectors 122 and 124, and m shows an integer.

[0032] Therefore, t can determine the propagation direction theta of the flux of light formed to the input light of wavelength lambda, if a specific value is given to m by the constant. Furthermore, in detail, the input light 77 is a specific angle and is diffused in a radial from the focal line 78. Therefore, the same input light of wavelength progresses in the direction in which

many differed from the focal line 78, and is reflected among reflectors 122 and 124. The light which progresses in the direction of specification [the conditions which suit in the slight strength of VIPA] suits in slight strength through interference of output light, and forms the flux of light which has a direction corresponding to the wavelength of input light. The light which progresses in the different direction from the specific direction demanded according to the conditions which suit in slight strength can be weakened by interference of output light.

[0033] Drawing 10 is line VIII-VIII of VIPA illustrated by drawing 6 which shows the property of VIPA for determining the degree of incident angle of the input light according to the operation gestalt of this invention, or an angle of inclination. It is drawing showing the cross section which met.

[0034] If drawing 10 is referred to, it will be condensed with a cylinder lens (un-illustrating), and will converge the input light 77 on the focal line 78. Like drawing 10 , the input light 77 covers a field with width of face equal to "a" on the irradiation window 126. After the input light 77 is reflected once from a reflector 122, incidence of the input light 77 is carried out on a reflector 124, and it covers the field of width of face equal to "b" on a reflector 124. Furthermore, the input light 77 is [as opposed to / the perpendicular of a reflector 122 / as shown in drawing 10] an angle of inclination theta 0. It progresses along with an optical axis 132.

[0035] Angle of inclination theta 0 After being first reflected by the reflector 122, it should be set up so that the input light 77 progresses and may not come out from the irradiation window 126. In other words, it is an angle of inclination theta 0. Input light 77 "should be captured" among reflectors 122 and 124, and it should be set up so that it may not escape from the irradiation window 126. Therefore, in order the input light 77 progresses and not to come out from the irradiation window 126, it is an angle of inclination theta 0. It should be set up according to the following formulas (2).

[0036] Inclination theta0 >= (a+b) of an optical axis / 4t (a+b) term serves as the minimum at the time of a=b. This is the situation that the focal line 78 is located on a reflector 122.

[0037] Therefore, the operation gestalt of this invention contains VIPA which receives the input light which has each wavelength of continuation within the limits of wavelength as shown in drawing 6 -10. VIPA makes autointerference start and makes output light form by the multiple echo of input light. Output light is spatially distinguishable from the output light formed to the input light of what other wavelength of continuation within the limits of wavelength. For example, drawing 8 is illustrating the input light which starts a multiple echo among reflectors 122 and 124. To each wavelength of the input light 77, as this multiple echo generates the distinguishable flux of light spatially, it generates two or more output light Out0, Out1, Out2, Out3, and Out4 in which it interferes mutually.

[0038] "Autointerference" is a term which shows interference produced between two or more light from the same light source, or a beam. Therefore, since the output light Out0, Out1, Out2, Out3, and Out4 is coming from the same light source (namely, input light 77) altogether, interference of the output light Out0, Out1, Out2, Out3, and Out4 is called autointerference of the input light 77.

[0039] According to the above-mentioned operation gestalt of this invention, input light may be what wavelength of continuation within the limits of wavelength. Therefore, input light is not limited to the wavelength which has the value chosen from the range of a dispersed value.

[0040] Furthermore, according to the above-mentioned operation gestalt of this invention, the output light generated to the input light of the specific wavelength of continuation within the limits of wavelength is spatially distinguishable from the output light generated when input light is the wavelength from which continuation within the limits of wavelength differs. When the input light 77 is the wavelength from which continuation within the limits of wavelength differs, the travelling direction (namely, "spatial property") of the flux of light 82 differs, as it follows, for example, is shown in drawing 6 . furthermore -- for example, -- if drawing 6 is referred to -- the input light 77 -- three wavelength lambda1, lambda2, and lambda3 -- when all are included, the flux of lights 82a, 82b, and 82c are generated simultaneously, and progress in the different direction

[0041] According to the above-mentioned operation form of this invention, it is indicated that a

focal line is on the field of the opposite side of the parallel board which input light inputs. However, a focal line can also be considered as this side of the field top of an irradiation window, or an irradiation window for example, in an parallel board.

[0042] According to the above-mentioned operation form of this invention, two reflective films reflect light by the meantime, and the reflection factor of one reflective film is 100% of abbreviation. However, the same effect can be acquired with no less than two reflective films which have a reflection factor smaller than 100%, respectively. For example, both the reflective film can have 95% of reflection factor. In this case, each reflective film makes light penetrate and makes interference cause. The flux of light which progresses in the direction depending on wavelength as a result is formed in the both sides of the parallel board with which the reflective film was formed. Therefore, the various reflection factors of the various operation forms of this invention can be easily changed according to the required property of VIPA.

[0043] According to the above-mentioned operation form of this invention, waveguide equipment is formed with an parallel board, or it is indicated being mutually formed of two parallel reflectors. However, this board or a reflector does not necessarily need to be parallel.

[0044] According to the above-mentioned operation form of this invention, VIPA uses a multiple echo and holds the fixed phase contrast between the light in which it interferes. As a result, the property of VIPA is stable and change of the optical property by the result and polarization is cut down. On the other hand, the optical property of the conventional diffraction grating receives change which is not desirable depending on the polarization of input light.

[0045] The above-mentioned operation form of this invention was indicated as what offers the flux of light mutually "spatially distinguishable." In space, the thing of the distinguishable flux of light is described distinction is "spatially possible." For example, it is collimated, and if condensed by point which progresses in the different direction or is different, various flux of lights are spatially distinguishable. However, this invention is not limited to these detailed examples, and other methods of enabling distinction of the flux of light spatially mutually exist.

[0046] Drawing 11 is drawing according to 1 operation form of this invention showing VIPA used with a receiver. According to drawing 11 , the multilayer reflective films 96 and 98 are formed in the both sides of the parallel board 100 which was able to be done with the glass which has thickness [of 100 micrometers] t. As for the parallel board 100, it is desirable to have the thickness of the range of 20-2000 micrometers. The reflective films 96 and 98 are multilayer quantity reflection factor interference films preferably.

[0047] The reflection factor of the reflective film 98 is 100% of abbreviation, and the reflection factor of the reflective film 96 is 95% of abbreviation. However, if sufficient light is reflected from the reflective film 96 so that it may not be limited to 95% but a multiple echo may happen among the reflective films 96 and 98, a different value is sufficient as the reflection factor of the reflective film 96. It is several% of range from 80% with the reflection factor of the reflective film 96 it is desirable and smaller than 100%. Furthermore, although the reflection factor of the reflective film 98 is not limited to 100%, it needs to be high enough to the grade which makes a multiple echo start among the reflective films 96 and 98.

[0048] The irradiation window 102 receives input light and is arranged on the same field as the reflective film 96 of the parallel board 100. The irradiation window 102 is formed on the field of the parallel board 100 with the film which has the reflection factor of 0% of abbreviation. As shown in drawing 11 , the boundary between the irradiation window 102 and the reflective film 96 is a straight line preferably.

[0049] Input light is outputted from an optical fiber (un-illustrating), and is received with a collimate lens 106. A collimate lens 106 changes input light into the collimated beam received with the cylinder lens 108. The cylinder lens 108 condenses a collimated beam 104 on the focal line 110 on the irradiation window 102. Near the boundary of the straight line between the reflective film 96 and the irradiation window 102, the focal line 110 is arranged in parallel. Thus, input light is inputted into the parallel board 100 through the irradiation window 102.

[0050] The optical axis of the input light 102 has the angle of inclination to the perpendicular of the reflective film 96, and after input light goes into the parallel board 100, it is made not to escape from the irradiation window 102. Therefore, an angle of inclination is set up according to

the above-mentioned formula (2).
[0051] Once, if input light enters in the parallel board 100, a multiple echo will be started among the reflective (for example, it is shown in drawing 8 like) films 96 and 98. Whenever input light carries out incidence to the reflective film 96, 95% of the abbreviation for light is reflected toward the reflective film 98, 5% of the abbreviation for light penetrates the reflective film 96, and they forms output light (for example, output light Out1 as shown in drawing 8). Two or more output light is formed of the multiple echo between the reflective film 96 and 98. It interferes in two or more output light mutually, and they forms the flux of light in the propagation direction depending on the wavelength of input light.
[0052] The flux of light 112 is condensed with the lens 114 which converges the flux of light on a convergent point. A convergent point moves along with the straight-line path 116 to the wavelength from which input light differs. For example, a convergent point moves in the distance further along with the straight-line path 116 as the wavelength of input light increases. Two or more receivers 118 are arranged on the straight-line path 116 in order to receive the condensed flux of light 112. Therefore, each receiver 118 is arranged so that the flux of light corresponding to specific wavelength may be received.
[0053] By controlling the reflective film of VIPA, or the distance t between reflectors, the environmental resistance which only the predetermined amount could shift the phase contrast of light reflected between a reflective film or a reflector, therefore was excellent is realizable. Furthermore, only a slight change causes the above-mentioned operation form of this invention about the optical property depending on optical polarization.
[0054] Drawing 12 is drawing according to another operation form of this invention showing VIPA used with a receiver. VIPA indicated by drawing 12 is the same as that of VIPA which the reflection factor of the reflective films 96 and 98 was replaced, and also was indicated by drawing 11 . In more detail, in VIPA indicated by drawing 12 , the reflective film 98 has the reflection factor of 95% of abbreviation, and the reflective film 96 has the reflection factor of 100% of abbreviation. As shown in drawing 12 , the flux of light 112 is formed of interference of the output light penetrated through the reflective film 98. Therefore, incidence of the input light is carried out from one side of the parallel board 100, and the flux of light 112 is formed in the opposite side of the parallel board 100. As for VIPA given in drawing 12 , others operate like VIPA given in drawing 11 .
[0055] Drawing 13 is drawing showing waveguide type VIPA according to 1 operation form of this invention. According to drawing 13 , light 138 is outputted from an optical fiber (un-illustrating), and is received by the waveguide 140 prepared in the substrate 142. A waveguide 140 is a lithium niobate. Light 138 contains the lightwave signal modulated on two or more carriers which have different wavelength.
[0056] Typically, light 138 has the diffused width of face, when outputted from an optical fiber. Therefore, a collimate lens 142 changes light 138 into parallel light. Next, it is condensed with the cylinder lens 144 and converges parallel light on the focal line 146. It emanates into VIPA148 from the focal line 146 through light and the irradiation window 150.
[0057] VIPA148 is equipped with the reflective films 152 and 154 on the parallel board 156. The reflective film 154 is in one side of the parallel board 156, and the reflective film 152 and the irradiation window 150 have it in the side of the parallel board 156 else. The reflective film 152 has the reflection factor of 100% of abbreviation, and the reflective film 154 has the reflection factor smaller than 100%. The flux of light 158 of light reflected by the parallel board 156 is outputted to an opposite side in the irradiation window 150 of the parallel board 156.
[0058] When the input light 138 contains two or more wavelength, two or more flux of lights 158 which progress in the different direction depending on the wavelength of the input light 138 are formed. The flux of light 158 formed of VIPA148 is condensed with a lens 160 by different point for which it depended in the propagation direction of the flux of light 158. Therefore, as shown in drawing 13 , the flux of lights 158a, 158b, and 158c which have wavelength lambda1, lambda2, and lambda3 are formed in a different condensing point, respectively.
[0059] Two or more light-receiving waveguides 162 are formed in a condensing point. Each light-receiving waveguide 162 leads the corresponding carrier which has a lightwave signal and single

wavelength. Therefore, light is received simultaneously and two or more flux of lights are sent out through various channels. Each light-receiving waveguide 162 has the corresponding receiver (un-illustrating) formed in the latter part. Typically, a receiver is optical diode. Therefore, the light drawn by each light-receiving waveguide 162 is processed after being received by the corresponding receiver.

[0060] However, according to VIPA by the above-mentioned operation form of this invention, the beam profile of the acquired flux of light is not the optimal beam profile. For example, drawing 14 (A) is drawing showing operation of drawing 7 of VIPA76, and drawing 14 (B) is drawing showing the beam profile of VIPA.

[0061] According to drawing 14 (A) and 14 (B), the input light 77 starts a multiple echo among the reflective films 122 and 124. In this example, it can be assumed that the reflective film 124 has the reflection factor of 100% of abbreviation, and the reflective film 122 has 95% of fixed reflection factor. By the multiple echo between the reflective films 122 and 124, the input light 77 becomes weak in VIPA76. Therefore, the flux of light generated by VIPA76 becomes weak along the field of the reflective film 122, as shown in drawing 14 (B). Therefore, the joint efficiency to the optical fiber of the flux of light is not so high. Since this problem is solved, it is possible to change the reflection factor of the reflective film 122.

[0062] For example, drawing 15 (A) shows operation of VIPA76 according to another operation form of this invention, and drawing 15 (B) is drawing showing the beam profile of VIPA of drawing 15 (A) according to 1 operation form of this invention.

[0063] According to drawing 15 (A), it can be assumed that the reflective film 124 has the reflection factor of 100% of abbreviation, for example. Furthermore, the beam profile of the acquired flux of light changes the reflection factor of the reflective film 122, for example, so that it may have a beam profile symmetrical with abbreviation like the abbreviation bell-like curve indicated by drawing 15 (B). For example, in the incidence position 180 of the beginning of the input light 77 of the reflective film 122, as for the reflection factor of the reflective film 122, it is possible to make it change so that more light may penetrate through the reflective film 122 through the reflective film 122 in the incidence position 182 of the last of the input light 77 of light where the reflective film 122 was reflected multiply so that only a part might penetrate very much. In a detail, more the reflection factor of the reflective film 122 preferably A reflection factor high near the first incidence position 180 (therefore, it sets in the first incidence position 180) It is made to change so that a slight light can be penetrated through the reflective film 122, and so that it may have a low reflection factor near the last incidence position 182 (therefore, more light can be penetrated through the reflective film 122 in the last incidence position 182 like).

[0064] For example, in the first incidence position 180, the reflective film 122 has 99% of abbreviation, and a reflection factor beyond it, and decrease in number to the reflection factor of 80% of abbreviation in the last incidence position 182. However, this invention is not limited to the range of this reflection factor. It is possible to design the reflective film 122 so that a reflection factor may change from the first incidence position 180 continuously toward the last incidence position 182.

[0065] Therefore, the input light 77 moves the optical incidence position on the reflective film 122 of the input light 77 toward the last incidence position 182 from the first incidence position 180, while multiple-times reflection is carried out among the reflective films 122 and 124. It is made for the flux of light decreased and acquired, having applied the reflection factor to the last incidence position from the first incidence position 180 along with the reflective film 122 to have a beam profile symmetrical with abbreviation along with the reflective film 122. Such a beam profile is shown in drawing 15 (B).

[0066] It is the graph with which drawing 16 (A) shows the example of the reflection factor curve (r) of the reflective film 122, and a permeability curve (t) according to 1 operation form of this invention, and drawing 16 (B) is a graph which shows a corresponding power reflective curve (R) and a power transmission curve (T). Here, generally it is T=t2 R=r2 (power is the square of an amplitude).

It is T+R=1.

[0067] It is t=kx if t is alignment. k is a constant here. And they are T=k2 x2 (parabola), R=1-k2 x2 (parabola), and r=root (1-k2 x2) (ellipse).
[0068] Therefore, with reference to drawing 16 (A) and 16 (B), it has the reflection factor as the reflective film 122 indicated to be to the reflection factor curve (r) of drawing 16 (A), and as shown in the permeability curve (t) of drawing 16 (A), it is assumed along the field of the reflective film 122 that an amplitude transmittance changes to alignment. Then, since power is the square of an amplitude, as shown in the above-mentioned formula, the power permeability curve (T) of drawing 16 (B) serves as a parabola type. Since a power reflection factor is power permeability to subtract one, similarly it serves as a parabola type like the power reflection factor curve (R) of drawing 16 (A). Although an output beam is combined with an optical fiber almost completely by using a power reflection factor curve (R), in VIPA of a fixed reflection factor, it has only 20% of loss, or 80% of joint efficiency.
[0069] according to alignment-change of an amplitude transmittance as shown in the permeability curve (t) — an output beam profile — perfect — not symmetrical — abbreviation — it is symmetrical However, this practical design gives a very high performance. Of course, a Gaussian type can be obtained to a completely symmetrical output or completeness by the design refined more. However, the complicated reflection factor curve of such a design is not practical.
[0070] It is better to keep constant preferably the optical phase between reflection by the reflective film 122, although a reflection factor changes along with the reflective film 122. Drawing 17 is drawing showing VIPA which has substantially regularity 184, i.e., the phase regulation buffer layer kept uniform, for an optical phase, while [according to 1 operation gestalt of this invention] being reflected. Preferably, among the reflective films 122 and 124, the phase regulation buffer layer 184 adjoins the reflective film 122, or is arranged at a it top. The thickness of the phase regulation buffer layer 184 changes along a front face, changes the optical phase of the light penetrated through the phase regulation buffer layer 184, and negates change of the optical phase which lets the reflection in the reflective film 122 pass.
[0071] The phase regulation buffer layer 184 expresses the suitable operation form to which the phase of the reflected light is changed. However, other composition is usable, in order that this invention may not be limited to this special operation form and may change the phase of the reflected light.
[0072] Furthermore, the optical phase in the light penetrated through the reflective film 122 should be preferably kept constant. Drawing 18 is drawing showing VIPA which has the phase regulation buffer layer 186 according to 1 operation form of this invention which keeps substantially constant, i.e., uniform, the optical phase of the light penetrated through the reflective film 122. The phase regulation buffer layer 186 is preferably arranged in the reflective film 124 along with the reflective film 122 at an opposite side. The thickness of the phase regulation buffer layer 186 changes along a front face, and negates the phase change drawn through the reflective film 122.
[0073] The phase adjustment buffer layer 186 expresses the suitable operation form to which the phase of the transmitted light is changed. However, other composition is usable, in order that this invention may not be limited to this special operation form and may change the phase of the transmitted light.
[0074] According to the above-mentioned operation form of this invention, VIPA has the 1st and the 2nd reflector (drawing 15 (A) is each the reflective film 124 and 122 grades). The 2nd field has a reflection factor which makes a part of light which carries out incidence penetrate. VIPA receives the input light of each wavelength of continuation within the limits of wavelength. Multiple-times reflection of the input light is carried out between the 1st and the 2nd field, and the 1st and the 2nd field are arranged so that two or more light may be penetrated through the 2nd field. It interferes in two or more transmitted lights mutually, and they generate a distinguishable output light (it is (like flux of light 82a of drawing 6 , or 82b)) spatially with the output light generated to the input light of what other wavelength of continuation within the limits of wavelength. The reflection factor of the 2nd field changes along the 2nd field, and output light has a desired beam profile along the 2nd field (see the beam profile of the reflective

film 122 of drawing 15 (A), and drawing 15 (B)). You may prepare a phase regulation buffer layer in order to give a uniform optical phase to the light reflected toward the 1st field from the 2nd field. Furthermore, a phase regulation layer can also be prepared in order to give a uniform optical phase to the transmitted light.

[0075] According to the above-mentioned operation form of this invention, the reflection factor of the front face of VIPA changes in order to obtain a desired beam profile. In a form with the above-mentioned various operation forms of this invention, the desired beam profile is indicated symmetrical. However, there may also be a situation that a different beam profile like the profile of asymmetry or a congruence wen configuration is required for example. Therefore, a reflection factor is not limited only in order to obtain a symmetrical beam profile. Rather, a reflection factor can be designed so that the beam profile of a request of the type with which many like the abbreviation bell-like curve of a symmetrical unsymmetrical Gaussian type or the beam profile of a congruence wen configuration differed, for example may be obtained. The beam profile of a congruence wen configuration is indicated by the U.S. applications 08/802,768 of February 21, 1997 application "the optical parts the distribution of the optical place of light-receiving light or whose distributions of the optical place of the propagating mode of a light-receiving waveguide are a congruence wen configuration", and is indicated as reference reference here.

[0076] It is possible to use the equipment containing VIPA combined with reflectors, such as a mirror, in order to generate a chromatism. For example, drawing 19 -23 are drawing having shown the equipment which uses VIPA as the angular-dispersion section for generating a chromatism. Such equipment is indicated in detail by the U.S. applications 08/796,842 of February 7, 1997 application "the optical equipment which uses a bar CHARI IMEJIDO phased array in order to generate a chromatism" and August 13, 1997 application, and the U.S. applications 08/910,251 "the optical equipment which uses a bar CHARI IMEJIDO phased array in order to generate a chromatism", and is indicated as reference reference here.

[0077] For example, if drawing 19 is referred to, VIPA240 has the 1st field 242 which has the reflection factor of 100% of abbreviation, and the 2nd field 244 which has the reflection factor of 98% of abbreviation. VIPA240 is equipped with the irradiation window 247 again. However, VIPA240 is not limited to this special composition. Rather, VIPA240 can take the composition from which many differed so that it may indicate here.

[0078] Light is outputted from a fiber 246, and is collimated by the collimate lens 248, and line condensing is carried out into VIPA240 through the irradiation window 247 with the cylinder lens 250 as shown in drawing 19 . VIPA240 generates from it the collimation light 251 which a convergent lens 252 converges on a mirror 254. A mirror 254 is good at the mirror part 256 formed on the substrate 258.

[0079] A mirror 254 minds a convergent lens 252, and reflects and returns light in VIPA240. From it, within VIPA240, light starts a multiple echo and is outputted from the irradiation window 247. The light outputted from the irradiation window 247 progresses through the cylinder lens 250 and a collimate lens 248, and is received with a fiber 246.

[0080] Therefore, it is outputted from VIPA240, it is reflected by the mirror 254, and light is returned to VIPA240. The light reflected by the mirror 254 progresses the path of opposite direction correctly [the path which has advanced first]. It is condensed by the position where mirrors 254 differ, and the wavelength component from which light differs is reflected and returned at VIPA240 so that the following may show in detail. As a result, a different wavelength component progresses a different distance, therefore generates a chromatism.

[0081] Drawing 20 is drawing showing more operation of VIPA of drawing 19 according to 1 operation form of this invention in a detail. Suppose that the light which has various wavelength components is received by VIPA240. As shown in drawing 20 , VIPA240 makes the virtual image 260 of a beam waist 262 form, and each virtual image 260 emits light.

[0082] A convergent lens 252 converges the wavelength component from which the collimation light from VIPA240 differs on the point that mirrors 254 differ as shown in drawing 20 . In more detail, it converges the long wave length 264 on a point 272, and it converges the main wavelength 266 on a point 270, and converges the short wavelength 268 on a point 274. And the long wave length 264 is returned to the near virtual image 260 by the beam waist 262 compared

with the main wavelength 266. The short wavelength 268 is returned to the further virtual image 260 from a beam waist 262 compared with the main wavelength 266. Therefore, a normal dispersion is given in this array.

[0083] A mirror 254 is designed so that only the light of a specific order of interference may be reflected, and it converges the light of any of other order of interference out of a mirror 254. In more detail, as mentioned above, VIPA outputs collimation light. It progresses in the direction in which the path from a virtual image makes m an integer, and this collimation light has difference mlambda. The m-th order of interference is defined as an output light corresponding to m.

[0084] For example, drawing 21 is drawing showing various degrees of interference of VIPA. According to drawing 21, VIPA like VIPA240 emits the collimation light 276, 278, and 280. Each collimation light 276, 278, and 280 corresponds to a different order of interference. Following, for example, using n as an integer, the collimation light 276 is the collimation light corresponding to the following (n+2) order of interference, the collimation light 278 is the collimation light corresponding to the following (n+1) order of interference, and the collimation light 280 is the collimation light corresponding to the n-th order of interference. The collimation light 276 is illustrated noting that it has some wavelength components 276a, 276b, and 276c. Similarly, the collimation light 278 is illustrated noting that it has the wavelength components 278a, 278b, and 278c, and the collimation light 280 is illustrated noting that it has the wavelength components 280a, 280b, and 280c. Here, the wavelength components 276a, 278a, and 280a have the same wavelength. The wavelength components 276b, 278b, and 280b have the same wavelength (however, it differs from the wavelength of the wavelength components 276a, 278a, and 280a). The wavelength components 276c, 278c, and 280c have the same wavelength (however, it differs from the wavelength of the wavelength components 276a, 278a, and 280a, and the wavelength of the wavelength components 276b, 278b, and 280b). Although drawing 21 is illustrating only the collimation light of three different order of interference, collimation light is emitted about much of other order of interference.

[0085] Since it converges the collimation light of the same wavelength of a different order of interference on a position which progresses in the different direction, therefore is different, a mirror 254 can reflect and return only light from a single order of interference to VIPA240. For example, the length of the reflective section of a mirror 254 is shortened comparatively, and it should be made to reflect only the light corresponding to a single order of interference as illustrated by drawing 21. In drawing 21, only the collimation light 278 is reflected more in a detail by the mirror 254. Thus, it converges the collimation light 276 and 278 out of a mirror 254.

[0086] Wavelength division multiplex light usually contains many channels. If drawing 19 is referred to once again and thickness t between the 1st and the 2nd field 242 and 244 of VIPA240 will be set as a specific value, it will become possible with this composition to compensate distribution of each channel simultaneously.

[0087] In the detail, each channel has main wavelength more. Such wavelength is usually isolated with the fixed frequency interval. All the wavelength components corresponding to main wavelength follow the same output angle from VIPA240, and thickness t of VIPA240 between the 1st and the 2nd field 242 and 244 should be set up so that it may have the same convergent point on a mirror 254. This is set up so that the optical path length of the round trip which passed along VIPA240 to which the wavelength component corresponding to main wavelength progresses thickness t to each channel may serve as an integral multiple of the main wavelength of each channel. The amount of this thickness t is hereafter called "WDM matching free spectral-range thickness" or "WDM matching FSR thickness."

[0088] Furthermore, the optical path length (2ntcostheta) of the round trip which passed along VIPA240 in this case is the same theta, and is equal to what carried out the integral multiple of the wavelength corresponding to the main wavelength of each channel to a different integer. Here, the propagation [n] direction of the refractive index of the member between the 1st and the 2nd field 242 and 244 flux of light corresponding to the main wavelength of each channel in theta is shown. More, as mentioned above, theta shows the propagation direction of the acquired flux of light measured from the line perpendicular to the field of reflectors 122 and 124 to a detail.

[0089] Therefore, if t is set up to the wavelength component corresponding to the main wavelength of each channel to the integer from which 2ntcostheta differs by the same theta so that it may be the integral multiple of the main wavelength of each channel, all the wavelength components corresponding to main wavelength have the same output angle from VIPA240, therefore the same convergence position of a mirror 254.
[0090] For example, it is the physical length (this is abbreviation double precision with a thickness [of VIPA240] of 1mm) of 2mm of round trips, and if it is refractive indexes 1 and 5, all the wavelength of a 100GHz interval can fulfill this condition. As a result, VIPA240 can compensate distribution of all the channels of wavelength division multiplex light simultaneously.
[0091] If drawing 20 is referred to, when thickness t will be set as WDM matching FSR thickness, therefore, VIPA240 and a convergent lens 252 (a) It converges the wavelength component corresponding to the main wavelength of each channel on the point 270 on a mirror 254. (b) It converges the wavelength component corresponding to the long wave length component of each channel on the point 272 on a mirror 254, and can converge the wavelength component corresponding to a wavelength component with (c) each short channel on the point 274 of a mirror 254. Therefore, VIPA240 can be used for compensating the chromatism of all the channels of wavelength division multiplex light.
[0092] Drawing 22 is a graph which shows the variance of several channels of the wavelength division multiplex light at the time of setting thickness t as WDM matching FSR thickness according to the operation gestalt of this invention. As shown in drawing 22 , all channels have the same distribution. However, distribution is not continuing between channels. Furthermore, the wavelength range over each channel which VIPA240 compensates for distribution can be set up by setting up the size of a mirror 254 suitably.
[0093] When thickness t is not set as WDM matching FSR thickness, the channel from which wavelength division multiplex light differs is converged on the point that mirrors 254 differ. For example, when thickness t is 1/2 of the optical-path-length thickness of a round trip, 1/3, or other fractions, it converges 2, 3, 4, or the convergent point of further many channels on the same mirror, and converges each channel on a different convergent point. More, when thickness t is 1/2 of WDM matching FSR thickness, a detail converges the light from odd channels on the same point of a mirror 254, and converges the light from even channels on the same point of a mirror 254. However, it converges the light from even channels on a point which is different in odd channels.
[0094] For example, drawing 23 is drawing showing a different channel which it converges on the point that mirrors 254 differ. It converges the wavelength component of the main wavelength of even channels on one point of a mirror 254, and converges the wavelength component of the main wavelength of odd channels on a different point as shown in drawing 23 . As a result, VIPA240 can fully compensate distribution of all the channels of wavelength division multiplex light simultaneously.
[0095] In drawing 19 -23, a fiber 246 functions as both the input fiber which supplies light to VIPA240, and an output fiber which receives the return light from VIPA240. However, in various designs, a fiber other than an output fiber is sufficient as an input fiber. Therefore, the I/O fiber of each other is distinguished spatially.
[0096] The 2nd field 244 of VIPA240 of drawing 19 -23 was indicated having had the reflection factor of 98% of abbreviation. However, as mentioned above, VIPA can be designed so that a desired beam profile may be generated, and it may have the field which changed the reflection factor. For example, the 2nd field 244 can also have the changing reflection factor which minimizes the loss of equipment or maximizes the joint efficiency from an input fiber to an output fiber. For example, the 2nd field 244 can have the changing reflection factor so that the beam profile of the request which cuts down the loss which takes place from a fiber 246 as light progresses to a mirror 254 to VIPA240 along with the total path which returns to VIPA240 and returns to a fiber 246 may be generated.
[0097] In order to cut down a loss and to acquire the highest joint efficiency, as for the 2nd field 244, it is desirable to give a Gaussian type or a beam profile with the abbreviation bell-like curvilinear configuration.

[0098] Therefore, VIPA is equipped with the reflector which generates a desired beam profile and which has the changing reflection factor as described above. For example, a reflector can have the changing reflection factor which generates an abbreviation Gaussian type beam profile or the output beam which has the beam profile of a congruence wen configuration along with a reflector along with the beam profile of an abbreviation bell-like curve, and a reflector along with a beam profile symmetrical with abbreviation, and a reflector along with a reflector. According to this contractor, such a beam profile configuration will be understood. Furthermore, according to this contractor, based on the above-mentioned publication, it will be recognized how the reflector which generates a desired beam profile is formed.

[0099] According to the above-mentioned operation gestalt of this invention, VIPA is indicated being formed of an parallel board or two reflectors parallel to each other. However, a board or a reflector does not necessarily need to be parallel.

[0100] According to the above-mentioned operation gestalt of this invention, the light containing two or more wavelength is separated spectrally simultaneously. Therefore, size of the receiver used for wavelength multiplex communication can be well made small.

[0101] According to the above-mentioned operation gestalt of this invention, VIPA can separate wavelength multiplex light spectrally simultaneously to each wavelength of input light. Furthermore, thickness t of the parallel board which forms VIPA can adjust a distributed angle. As a result, a distributed angle can be enough enlarged so that a receiver can receive the signal each separated spectrally easily. For example, the conventional diffraction grating needs a concavo-convex side minute for a big distributed angle. However, it is very difficult to prepare a minute concavo-convex field, therefore it limits the size of a distributed angle. On the other hand, VIPA according to the above-mentioned operation gestalt of this invention is good only by changing the thickness of an parallel board, in order to realize a comparatively big distributed angle.

[0102] Furthermore, VIPA by the above-mentioned operation gestalt of this invention generates a bigger distributed angle than the conventional diffraction grating. Therefore, the receiver which uses VIPA according to the above-mentioned operation gestalt of this invention can receive a lightwave signal correctly rightly also in the wavelength multiplex communication which realizes high-level multi-processing. Furthermore, such a receiver has comparatively easy composition, and although manufactured, it is comparatively cheap.

[0103] According to the above-mentioned operation gestalt of this invention, VIPA uses a multiple echo and holds the fixed phase contrast between the light in which it interferes. As a result, the property of VIPA is stable, therefore change of the optical property produced by polarization is lessened. On the other hand, the optical property of the conventional diffraction grating receives change which is not desirable depending on the polarization of input light.

[0104] Furthermore, as compared with a waveguide array grid, VIPA by the above-mentioned operation gestalt of this invention is comparatively easy composition, and attains a stable optical property and the resistance over change of an environmental condition.

[0105] In the above-mentioned operation gestalt of this invention, VIPA has the reflective film for reflecting light. For example, since light is reflected, drawing 7 shows VIPA76 which has the reflective films 122 and 124. However, it is not limited to VIPA using a "film", in order to prepare a reflector. Rather, VIPA should only have the suitable reflector, and these reflectors do not need to be carried out even if formed as a "film."

[0106] Furthermore, in the above-mentioned operation gestalt of this invention, VIPA contains the board of the transparent glass with which a multiple echo happens inside. For example, drawing 7 shows VIPA76 which has the board 120 of the transparent glass which has a reflector on it. However, VIPA is not limited to using a glass member and what type of "board", in order to isolate a reflector. Rather, the reflector should only be isolated mutually. For example, it has the reflector held by being stabilized by member like not the board of glass but the small glass metallurgy group of thermal expansion, and the reflector of VIPA can only have "air" in the meantime. Therefore, a reflector can be indicated as what has the transparent member which are optical glass and air in the meantime.

[0107] Some suitable operation forms of this invention are shown, and although indicated, it will

be recognized that these operation forms can be transformed, without separating from the principle and soul of invention which are specified by the claim or its equal object according to this contractor.

[Translation done.]